学 位 論 文

論文題目

パノラマエックス線写真の骨粗鬆症スクリーニング指標と現在歯数との関連

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松本歯科大学大学院歯学独立研究科博士（歯学）学位申請論文

Association between number of teeth present and mandibular cortical erosion in Japanese men and women aged 40 years and older: a cross-sectional study

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《要旨》

パノラマX線写真で検出された下顎骨皮質骨の粗鬆化は高齢者の骨粗鬆症のリスクの増加と関連している。さらに、多くの報告では歯の喪失と骨粗鬆症の間の関連性を実証している。しかし、下顎骨皮質骨の粗鬆化が歯の喪失と関連は不明である。そこで、本研究の目的は、40歳以上の日本人の男女の下顎骨皮質骨の粗鬆化と、現在歯数との関連を明らかにすることした。

本学大学病院を受診し、歯科治療のためパノラマX線写真を撮影した839名（男性　293名、女性　546名）の患者で、年齢は40歳から89歳（平均[SD]　63．7歳　[10．6]）を被験者とした。

重回帰分析では、軽度から中等度粗鬆化（P＝0.007）、そして高度粗鬆化（P<0.001）が歯の喪失と有意に関連していた。共変量分散分析にて寄与因子を補正した分析では、下顎骨の粗鬆化と現在歯数との間に有意な関連を示した（P＜0.001）。高度粗鬆化の被験者は正常な皮質骨の被験者（平均[SE]20．7本[0．5]　vs　23．4本[0．3]、P<0.001）と、軽度から中等度粗鬆化（22．2本[0．4]、P=0.04）の被験者に比べ有意に少ない歯数を示した。軽度から中等度粗鬆化の被験者は正常な皮質骨の被験者（P=0.033）に比べ有意に少ない歯数示した。

我々の結果は、40歳以上の日本人男女の皮質骨の粗鬆化と現在歯数の有意な関連を示した。

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Original Article

Association between number of teeth present and mandibular cortical erosion in Japanese men and women aged 40 years and older: A cross-sectional study

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Abstract

Mandibular cortical erosion detected on dental panoramic radiographs is associated with increased risk of osteoporosis in older adults. Additionally, many reports have demonstrated an association between decreased number of teeth present and osteoporosis. However, whether mandibular cortical erosion is associated with a decreased number of teeth remains unclear. The purpose of this study, therefore, was to clarify the association between mandibular cortical erosion and number of teeth present in Japanese men and women aged 40 years and older. Among patients who visited our university hospital and underwent dental panoramic radiography for the diagnosis of dental diseases, 839 patients (293 men and 546 women) aged 40–89 years (mean [SD], 63.7 [10.6] years) participated in this study. Multiple regression analysis revealed that mildly to moderately eroded cortex ($p = 0.007$) and severe eroded cortex ($p < 0.001$) were significantly associated with a decreased number of teeth present. Analysis of covariance adjusted for covariates revealed a significant association between mandibular cortical erosion category and number of teeth present ($p < 0.001$). Subjects with a severely eroded cortex had significantly fewer teeth present than those with a normal cortex (mean [SE], 20.7 [0.5] vs. 23.4 [0.3], $p < 0.001$) or mildly to moderately eroded cortex (22.2 [0.4], $p = 0.04$). Subjects with a mildly to moderately eroded cortex had significantly fewer teeth present than those with a normal cortex ($p = 0.033$). Our results suggest the significant association between mandibular cortical erosion and number of teeth present in Japanese men and women aged 40 years and older.

Keywords: Mandible; Cortex; Panoramic radiography; Osteoporosis; Tooth

1. Introduction

Osteoporotic fractures are a crucial burden worldwide and can result in an increased risk of subsequent fractures, morbidity, and mortality [1]. The global incidence of fractures has gradually decreased except in Asia [2]. In particular, the incidence rate of osteoporotic fractures in Japan continues to increase; there are approximately 13 million patients with osteoporosis and 170,000 femoral neck fractures occur annually [3]. One potential explanation may be insufficient identification of patients at risk of osteoporotic fractures. In fact, only 30% of patients with osteoporosis receive some type of therapy for osteoporosis in Japan [4].

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Since 1994, we have investigated the usefulness of mandibular cortical shape, namely the mandibular cortical index (MCI), detected on dental panoramic radiographs, which are widely used in general dental practice for the diagnosis of dental diseases [5]. We have demonstrated associations between the MCI and osteoporosis diagnosis determined by bone mineral density (BMD) measured by dual energy X-ray absorptiometry [6,7]; the MCI and biochemical markers of bone turnover [8]; and the MCI and risk of osteoporotic fractures [9]. Additionally, a recent meta-analysis indicated the usefulness of the MCI for identification of asymptomatic individuals at risk of osteoporosis [10].

Daniell demonstrated the association between osteoporosis and increased risk of tooth loss in postmenopausal women [11]. Since then, many investigators have confirmed the association between osteoporosis and tooth loss in the elderly worldwide, including Japan and Korea [12–14]. Furthermore, Wactawski-Wende suggested a potential mechanism by which systemic bone density loss during osteoporosis may provide a host system that is increasingly susceptible to destruction of periodontal tissue by infection, resulting in tooth loss [15]. Nevertheless, if a positive association between osteoporosis and tooth loss exists, then it is likely that the MCI detected on dental panoramic radiographs may be associated with number of teeth present in the elderly. The purpose of this study, therefore, is to clarify the association between the MCI and number of teeth present in Japanese men and women aged 40 years and older.

2. Materials and methods

2.1. Subjects and panoramic radiography measure

Among patients who visited our university hospital and underwent dental panoramic radiography for the diagnosis of dental diseases between January 2007 and December 2013, 2187 men and women aged ≥40 years were invited to complete a structured questionnaire. Patients who refused to provide written informed consent, had destructive jaw lesions such as osteomyelitis and malignant tumors, or were receiving cancer medications were excluded from the study. The subjects completed the structured questionnaire, which collected information regarding body height (cm), body weight (kg), history of smoking and alcohol consumption, history of hypertension, diabetes mellitus, and rheumatoid arthritis, daily number of tooth brushings (<2 or ≥2), use of inter-dental brush or floss, and use of osteoporosis medications. We selected the factors included in the covariance from FRAX [16]. Additionally, since we previously demonstrated the significant association between loss of teeth and hypertension, we collected the information about hypertension [17].

Dental panoramic radiographs were obtained with an AZ-3000 instrument (Asahi, Kyoto, Japan). Four experienced radiologic technologists took these radiographs. A digital radiography system (Regius Model 170; Konica Minolta Holdings, Tokyo, Japan) was used for the radiographs in all subjects. The panoramic radiographs were prepared using a laser imager (Drypro SD-P, Konica Minolta Holdings, Tokyo, Japan). All the panoramic radiographs used in this study were suitable for taking the measurements. MCIs of all dental panoramic radiographs were determined by an oral radiologist (A.T., with 26 years clinical experience) who was blinded to the number of teeth present by masking the alveolar bone area of the jaws.

The MCI was determined by observing the mandible distally from the mental foramen bilaterally and categorized into one of three groups as previously described [6]: normal cortex: the endosteal margin of the cortex is even and sharp on both sides; mildly to moderately eroded cortex: the endosteal margin shows semilunar defects (lacunar resorption) or appears to form endosteal cortical residues; severely eroded cortex: the cortical layer forms heavy endosteal cortical residues and is clearly porous (Fig. 1). The number of teeth present was counted on dental panoramic radiographs by another dentist (S.Y.). This study was carried out in accordance with the Declaration of Helsinki. The ethics committee of our university reviewed and approved the study protocol (No. 0152). Written informed consent was obtained from all subjects prior to enrollment.

2.2. Statistical analysis

Main observer (A.T.) and another observer (K.U.) independently determined MCIs of 200 dental panoramic radiographs randomly selected from those of the participants. Intra- and inter-observer agreement was calculated by the weighted kappa statistic, respectively. Continuous variables are expressed as means ± standard deviation (SD). The Chi-squared test or one-way analysis of variance was used to investigate differences in number of teeth present, age, gender, body height (cm), body weight (kg), history of smoking (yes or no) and alcohol consumption (yes or no), history of hypertension (yes or no), diabetes mellitus (yes or no), and rheumatoid arthritis (yes or no), daily number of tooth brushings, use of inter-dental brush or floss (yes or no), and use of osteoporosis medications (yes or no) among the three MCI categories. Multiple regression analysis in a stepwise manner, adjusted for the abovementioned variables, was used to clarify the association between number of teeth present and MCI category. Dummy variables were used for categorical data in this multiple regression analysis.

Analysis of covariance (ANCOVA), adjusted for age, gender, body height (cm), body weight (kg), history of smoking (yes or no) and alcohol consumption (yes or no), history of hypertension (yes or no), diabetes mellitus (yes or no), and rheumatoid arthritis (yes or no), daily number of tooth brushings, use of inter-dental brush or floss (yes or no), and use of osteoporosis medications (yes or no), was used to evaluate differences in the number of teeth present among the three MCI categories. All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS, version 19.0; IBM Inc., Armonk, NY, USA). P values <0.05 were considered to indicate statistical significance.

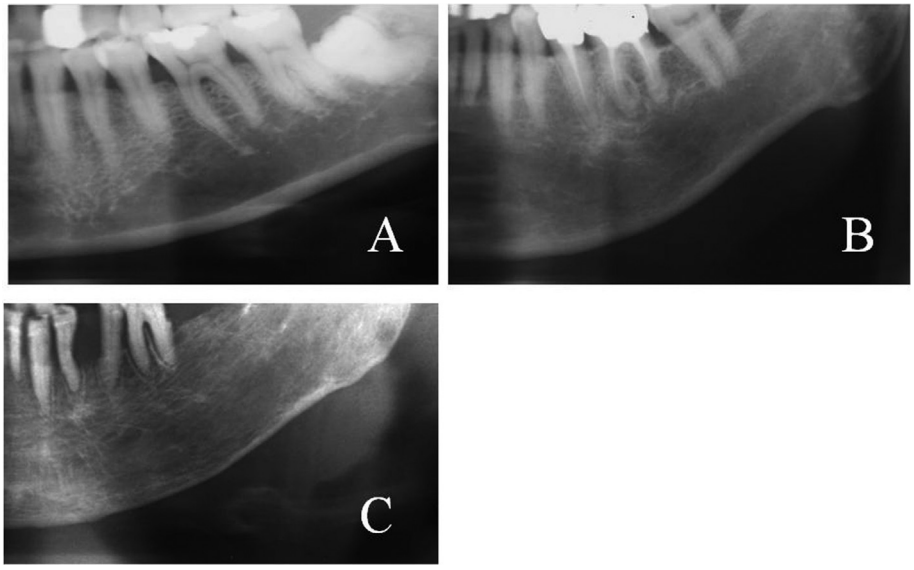

Fig. 1. Mandibular cortical shape on panoramic radiographs. (A) Normal cortex: the endosteal margin of the cortex is even and sharp on both sides; (B) mildly to moderately eroded cortex: the endosteal margin shows semilunar defects (lacunar resorption) or appears to form endosteal cortical residues; (C) severely eroded cortex: the cortical layer forms heavy endosteal cortical residues and is clearly porous.

3. Results

Of 2187 patients aged ≥40 years initially invited to participate, 1021 patients (371 men and 650 women) aged 40–89 years gave informed consent to participate in our study. After excluding patients based on exclusion criteria, 839 patients (293 men and 546 women) aged 40–89 years (mean [SD], 63.7 [10.6] years) were finally enrolled in this study. The characteristics of the study subjects are shown in Table 1. Four hundred and ninety-five subjects had a normal mandibular cortex, 234 had a mildly to moderately eroded cortex, and 100 had a severe eroded cortex. Weighted kappa for intra- and inter-observer agreement for determining MCI was 0.87 (95% confidence interval [CI], 0.80–0.93) and 0.71 (95% CI, 0.61–0.80), respectively. Thirty subjects used oral bisphosphonate (BP), 10 used selective estrogen receptor modulator, and 6 used vitamin D for osteoporosis treatment. Table 2 shows the differences in subject characteristics according to MCI category. Significant differences were observed in number of teeth present ($p < 0.001$), gender ($p < 0.001$), age ($p < 0.001$), body height ($p < 0.001$), body weight ($p < 0.001$), history of hypertension ($p = 0.037$), alcohol consumption ($p = 0.002$), smoking ($p < 0.001$), and use of osteoporosis medications ($p < 0.001$).

Table 1
Characteristics of 839 study subjects.

	Men	Women
Number of subjects	293	546
Age (years)	67.7 (8.1)	61.5 (11.2)
Height (cm)	167.1 (6.6)	155.3 (5.6)
Weight (kg)	64.2 (9.4)	52.7 (8.8)
Number of teeth present	22.0 (6.0)	23.1 (5.6)
Diabetes mellitus (yes)	39 (13.3)	24 (4.4)
Rheumatoid arthritis (yes)	5 (1.7)	10 (1.8)
Hypertension (yes)	105 (35.8)	126 (23.1)
Daily number of tooth brushing (≥2)	212 (72.4)	504 (92.3)
Use of inter-dental brush or floss	169 (57.7)	405 (74.2)
Alcohol consumption (yes)	179 (61.1)	148 (27.1)
Smoking history (yes)	141 (48.1)	57 (10.4)
Use of osteoporosis medications	3 (1.0)	43 (7.9)

Data are expressed as mean (SD) or number of subjects (%).

Multiple regression analysis revealed that mildly to moderately eroded cortex ($p = 0.007$), severe eroded cortex ($p < 0.001$), advancing age ($p < 0.001$), and history of smoking ($p = 0.001$) were significantly associated with a decreased number of teeth present (Table 3). Conversely, increased number of tooth brushings ($p < 0.001$), use of inter-dental brush or floss ($p < 0.001$), history of alcohol consumption (yes) ($p = 0.009$), and use of osteoporosis medications ($p = 0.033$) were significantly associated with an increased number of teeth present.

Additionally, ANCOVA revealed a significant association between MCI category and number of teeth present ($p < 0.001$) (Fig. 2). Subjects with a severely eroded cortex had significantly fewer teeth present than those with a normal cortex (mean [SE], 20.7 [0.5] vs. 23.4 [0.3], $p < 0.001$) or mildly to moderately eroded cortex (20.7 [0.5] vs. 22.2 [0.4], $p = 0.04$). Subjects with a mildly to moderately eroded cortex had significantly fewer teeth present than those with a normal cortex (22.2 [0.4] vs. 23.4 [0.3], $p = 0.033$).

4. Discussion

To our knowledge, this is the first study demonstrating the association between MCI category and number of teeth present in Japanese men and women aged 40 years and older, although the association between MCI category and osteoporosis diagnosis has been reported [10]. We previously demonstrated an association between mandibular cortical width measured on dental panoramic radiographs and number of teeth present, without adjusting for covariates that may

Table 2
Differences in subject characteristics according to mandibular cortical shape detected on dental panoramic radiographs.

Cortical shape	Normal cortex	Mildly to moderately eroded cortex	Severely eroded cortex	P-value
Number of subjects	495	234	110	
Gender (women)	273	173	100	<0.001
Age (years)	60.8 (11.4)	67.3 (8.1)	69.0 (6.8)	<0.001
Height (cm)	161.4 (7.9)	157.3 (8.2)	155.3 (6.8)	<0.001
Weight (kg)	58.4 (10.4)	55.0 (10.3)	52.6 (10.2)	<0.001
Number of teeth present	23.7 (5.1)	21.7 (6.2)	20.2 (6.3)	<0.001
Diabetes mellitus (yes)	34	21	8	0.599
Rheumatoid arthritis (yes)	7	5	3	0.574
Hypertension (yes)	120	76	35	0.037
Daily number of tooth brushings (≥2)	424	199	82	0.946
Use of inter-dental brush or floss	330	162	82	0.261
Alcohol consumption (yes)	217	79	31	0.002
Smoking history (yes)	141	43	14	<0.001
Use of osteoporosis medications	13	14	19	<0.001

Data are expressed as mean (SD) or number of subjects.

Table 3
Associations between number of teeth present and mandibular cortical shape detected on dental panoramic radiographs determined by multiple regression analysis.

	Parameter estimate	SE	P-value
Mildly to moderately eroded cortex	−1.186	0.438	0.007
Severely eroded cortex	−2.723	0.590	<0.001
Age (year)	−0.147	0.018	<0.001
Use of inter-dental brush or floss	1.398	0.397	<0.001
Smoking history (yes)	−1.570	0.454	0.001
Alcohol consumption (yes)	1.008	0.387	0.009
Daily number of tooth brushings (≥2)	1.186	0.534	0.027
Use of osteoporosis medications	1.767	0.825	0.033

SE: standard error of the mean.

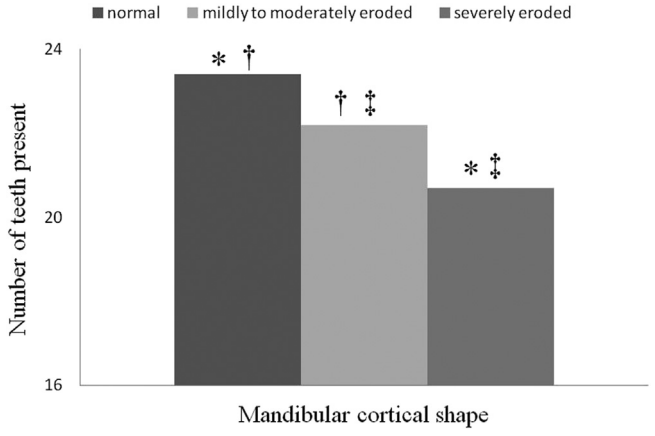

Fig. 2. Association between mandibular cortical shape on panoramic radiographs and number of teeth present. *p < 0.001; †, ‡p < 0.05.

affect tooth loss [18]. We recently reported a significant association between increased self-reported kyphosis and increased risk of spine fractures in 407 Japanese women aged 60 years and older [19]. Additionally, we also demonstrated a significant association among increased self-reported kyphosis, number of teeth present, and number of teeth lost within 1 year in 307 Japanese men and women aged 50 years and older [20]. Our findings suggest that individuals who have osteoporosis may lose more teeth than those who do not have osteoporosis. Our current study supports this hypothesis. However, since this is the cross-sectional study, it remains unclear whether osteoporotic change of the mandible contributes to increased risk of tooth loss. It is possible that tooth loss may accelerate the progression of mandibular cortical erosion.

Fig. 3 shows dental panoramic radiographs of a 56-year-old female patient who had a severe atrophic edentulous mandible and normal cortex. She had lost multiple teeth because of dental caries before 40 years of age. If an edentulous status contributes to mandibular cortical erosion, then this patient should have a severely eroded cortex. However, BMDs of both the spine and femoral neck in this patient were within normal ranges (both T scores were approximately 0). Thus, this case suggests that tooth loss does not accelerate the progression of mandibular cortical erosion. Additionally, we previously demonstrated no association between severe mandibular atrophy and osteoporosis in Japanese postmenopausal women and Caucasian men and women [21,22].

Fig. 4 shows dental panoramic radiographs of a 57-year-old female patient who had a severely eroded cortex. This patient had lost only one tooth because of dental caries. If a

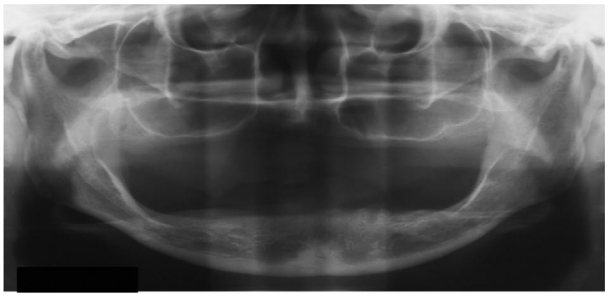

Fig. 3. Dental panoramic radiographs of a 56-year-old female patient who had severe atrophic edentulous mandible and normal cortex.

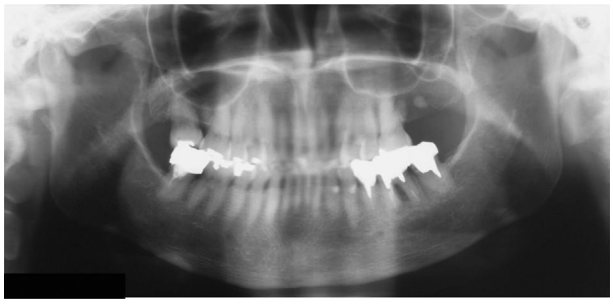

Fig. 4. Dental panoramic radiographs of a 57-year-old female patient who had a severely eroded cortex.

dentate status prevents mandibular cortical erosion, then this patient should have a normal cortex. However, T-scores of both the spine and femoral neck in this patient were less than −2.5. Thus, this case suggests that the presence of teeth does not protect against the progression of mandibular cortical erosion.

In this study, use of osteoporosis medications was significantly associated with an increased number of teeth present. This result is in accordance with that of previous studies [23−26]. Furthermore, many investigators have reported the improvement of periodontal disease by oral BP therapy for osteoporosis treatment [27−29]. It is reasonable that advancing age and history of smoking had negative effects on tooth retention. It also is likely that increased number of tooth brushings and use of inter-dental brush or floss may be effective for tooth retention in men and women aged 40 years and older. However, whether history of alcohol consumption has a positive effect on tooth retention remains unclear. Morita et al. reported that factors significantly associated with tooth loss in both males and females included alcohol consumption (odds ratio [OR] = 11.96, males; OR = 3.83, females) in 777 Japanese people aged 20 years and older (390 men and 387 women) [30]. Conversely, Hanioka et al. reported that current alcohol drinking was significantly associated with decreased risk of tooth loss (adjusted OR [95% confidence interval], 0.28 [0.07−0.84]) in 1219 Japanese women aged 60 years or older [31]. However, there was no significant association between former alcohol drinking and tooth loss in 903 men and 1291 women or between current alcohol drinking and tooth loss in men. Significant associations were not observed in these subjects; however, all adjusted ORs were less than 1, suggesting that alcohol consumption may have a positive effect on tooth retention in Japanese men and women aged 60 years and older.

There are some limitations associated with this study. First, the study population consisted of patients who visited our university hospital. Thus, our cohort may not be representative of Japanese men and women aged 40 years and older. Second, the study had a cross-sectional, rather than longitudinal, design. Therefore, it is necessary to evaluate the association between number of teeth lost after baseline and the MCI after adjusting for covariates to clarify whether the number of teeth lost after baseline can be predicted by the MCI. Third, osteoporosis medications might contribute to the MCI detected on dental panoramic radiographs. However, a significant association between MCI category and number of teeth present remained after adjusting for use of osteoporosis medications. Lastly, the reason for tooth should be evaluated to determine whether periodontal disease actually contributes to tooth loss in patients who have mandibular cortical erosion detected on dental panoramic radiographs.

5. Conclusions

Our results suggested the significant association between mandibular cortical erosion and number of teeth present in Japanese men and women aged 40 years and older. A longitudinal study is necessary to clarify whether future tooth loss can be predicted by MCI category on dental panoramic radiographs.

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Conflicts of interest

None.

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